Too old for abstr

Breeding Cottons Resistant to Bacterial Blight Disease

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CONTENTS

Cover Picture

In the cotton plant shown on the cover, the center leaf (marked by white tag) has been turned with its underside exposed to show the typical symptoms of bacterial blight disease. The leaf immediately to the right shows some symptoms on its upper surface.

Agricultural Experiment Station, University of Arkansas College of Agriculture. Lippert S. Ellis, director; Dwight Isely, associate director. Main Station, University; with Cotton Branch Station, Lee County, John L. Dameron, assistant director in charge; Rice Branch Station, Arkansas County; Fruit and Truck Branch Station, Hempstead County; and Livestock and Forestry Branch Station, Independence County. DPL2.5M653

BREEDING COTTONS RESISTANT TO BACTERIAL BLIGHT DISEASE

Black Arm

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This paper reports a study on the breeding of cottons resistant to the bacterial blight disease. In the never-ending search for cottons that will produce fiber superior to that currently in production, it is necessary to study many factors, from both a genetic and an environmental standpoint, to learn the factors that affect fiber quality. Primarily, the cotton plant must be healthy. The plant may be unhealthy due to malnutrition or other non-parasitic diseases, insect attacks, or parasitic disease injury. Poor-quality fiber resulting from these deterrents to normal development places cotton at a disadvantage in competition with semi-synthetic and synthetic fibers.

The bacterial blight disease of cotton caused by the bacterium *Xanthomonas malvacearum* (E. F. Sm.) Dowson, is, according to Neal (6) ". . . variously called bacterial boll rot, angular leaf spot, vein blight, and blackarm, depending upon part of plant attacked." The cotton plant is subject to attack by bacterial blight at any stage of growth. The disease may cause the cotyledonary leaves to shed prematurely, reducing the photosynthetic area, and result in retarded seedling growth; or cotyledons may remain attached to the plant, harboring the disease until it is spread to other parts of the plant. During the period from beginning of first blooms to full crop maturity, the leaves may be attacked causing them to shed; and in severe epidemics, a large percentage of the plant's photosynthetic area is destroyed. The plants in this denuded condition may not be able to support the developing fiber in the green bolls; as a result, the fiber produced is immature and poor in quality. When the green bolls are attacked and the organism penetrates beyond the inner carpel wall, the young fiber is injured or its usefulness is impaired.

The extent of the damage caused by bacterial blight varies from year to year over the cotton belt as a whole. In 1934 Miles (5) reported from Mississippi that "In many fields, practically one hundred per cent infection occurred." In some localities, injury in epidemic proportion is present almost every season.

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Selection for Plants Resistant to Bacterial Blight

In view of the need for a commercial variety of cotton resistant to bacterial blight, selection work was begun at Greenville, Texas, in 1946. Simpson and Weindling (7) observed in that year "... none of the important commercial varieties in this country are highly resistant." In 1948 the breeding work was transferred to Marianna, Arkansas.

In beginning the work at Greenville, the writer was motivated in plan of action by results of a study made of bacterial-blight-injured bolls for a number of varieties over a period of years. Open boll samples were collected from each variety in the commercial variety test each year; and during the usual process of analyzing the boll samples in the laboratory for various properties, the bur and seed cotton of each boll was examined for bacterial blight injury. The organisms present in the injured bolls were not plated out in a pathological approach to identification. The visual inspection system used in classifying the bolls as being injured by bacterial blight probably was subject to some error. However, during the period in question, there was little rain during the latter part of the season and it is not likely the green bolls were damaged by organisms other than bacterial blight. The bacterial blight lesions were clearly distinguishable on the dry carpel walls.

When the counts of bolls injured by bacterial blight were summated, it was apparent that some varieties had relatively few bolls damaged while other varieties had a considerable percentage of total bolls infected. When data for more than two years of the survey work were available, it was decided to begin selecting for resistance within the commercial variety Stoneville 2B which had the lowest relative amount of infection.

During the summer of 1946, a search for resistant plants was made in a field of Stoneville 2B aggregating approximately twenty thousand plants. The field was thoroughly infested with the blight organism, as was indicated by leaf infection symptoms in the form of angular water-soaked lesions. Only four plants were found free of bacterial blight injury in the area examined for infection symptoms. These plants were tagged and selfing and crossing work was begun immediately. The four selections were given the progeny designations: Stoneville 2B-1, -2, -3, and -4. The progeny, Stoneville 2B-2 being deficient in desirable qualities, was discarded after the second generation.

The progeny designations of the selections resistant to bacterial blight were changed to BBR-1, BBR-3, and BBR-4, BBR meaning bacterial-blight-resistant. These stocks have continued to show resistance to bacterial blight up to the present time. (Table 1.)

TABLE 1. Number of Resistant and Susceptible Plants Produced by Each of the Three Original Selections

Locations and years	Progenies and check plot plants[1]											
	BBR-1		Check plots		BBR-3		Check plots		BBR-4		Check plots	
	R	S	R	S	R	S	R	S	R	S	R	S
Greenville, Texas												
1946	1	—	—	—	1	—	—	-	1	—	—	—
1947	17	—	—	15	19	—	—	15	9	—	—	—
Marianna, Arkansas												
1948	217	—	—	99	252		—	82	37		—	34
1949	438	30	—	152	356	19	—	79	281	6	—	52
1950	459	5	—	153	666	7	—	387	96	—	—	31
1951	151	—	—	37	195	—	—	31	104	—	—	—
1952	40	—	—	14	59	—	—		58	—	—	10

[1] Symbols: BBR—bacterial blight resistant; R—resistant plants; S—susceptible plants.

Method Used in Inducing Artificial Epidemics of Bacterial Blight

Natural epidemics of bacterial blight were not sufficiently uniform to give a thorough test of resistance; consequently, a means of inducing artificial epidemics was employed.

While the breeding work was being conducted at Greenville, bacterial blight inoculum was applied to the plants with a three-gallon tank sprayer at a pressure of 25 to 30 pounds per square inch; and later, at Marianna, Arkansas, the pressure per square inch was increased to 35 to 40 pounds with a larger spray machine.

Beginning with the initial plant selections and continuing through 1948, generations grown in the field and succeeding generations grown in the greenhouse were subjected to artificial inoculations and, subsequently, examined for infection symptoms. The inoculum used was prepared from a culture of the bacterial blight organism.[2] The inoculum was applied to the under surface of the leaves to permit access of the organism to the greater number of stomatal openings and also to reduce the danger of too rapid evaporation. The inoculum was applied between the hours of 10 a. m. and 4 p. m.

[2] This culture and that used in the two succeeding field generations was furnished by Lester M. Blank, Plant Pathologist, U. S. D. A., then stationed at College Station, Texas. Dr. Blank grew two generations of the resistant stock in the greenhouse during the winter seasons of 1946 to 1947 and 1947 to 1948 and determined resistant qualities.

The generations grown in the field were interspersed with plots of susceptible varieties to serve as checks on viability of the inoculum used and effectiveness of application.

To insure positive contact of the inoculum, the plants were sprayed twice each season. The first application was made six to seven weeks from date of planting, or when the first blooms appeared. The second application followed the first by approximately 14 days.

Beginning with the second application of inoculum in 1948, a watery suspension of the bacterial blight organism was used in determining resistance or susceptibility. The method used by the writer in preparing a watery suspension of the bacteria was a modification of the method developed by Knight and Clouston (3) in which they prepared an inoculum by soaking 10 pounds of infected leaves in 40 gallons of water for two hours. After being filtered, their inoculum was applied by using knapsack sprayers. In the modified method used by the writer, the infected leaves were immersed in tap water and permitted to soak for a few minutes; then they were finely ground with a food cutter. The ground leaf material was immersed again in tap water and stirred constantly for approximately an hour. The inoculum thus prepared was filtered into the tank of a cart sprayer and applied to the plants.

Difficulty was experienced in obtaining normal activity of the inoculum when the ground, infected leaf material was immersed in cold tap water. Massey (4), working in the Sudan, observed: "Temperatures directly affected the intensity of infection, many more lesions being obtained with a warm spray 32° C (89.6° F) . . ."

It was observed at Marianna that bacterial blight inoculum, prepared from a laboratory culture received from College Station, Texas, seemed to be more potent than the watery suspension in overcoming resistance offered by resistant plants.

Effects of Environmental Conditions

Environmental conditions favoring activity of the bacterial blight organism prevailed during the crop years of 1946 through 1952 with the exception of 1950. The day and night temperatures were high; soil moisture was ample for succulent growth of the plants; and the relative humidity was generally high. Certain environmental conditions during the crop season of 1950 were adverse to the development and spread of the blight organism. The day and

night temperatures were abnormally low throughout the growth period. Similar effects of environmental conditions were noted by Bird and Blank in Texas (1), "Apparently environmental conditions in 1950 were not favorable to secondary spread of the disease . . ."

During the crop seasons of 1949 to 1952, inclusive, an overhead sprinkler type irrigation system was used to supplement soil moisture during the dry periods. Without this supplemental addition of water to the soil, the cotton plants would have undergone periods of water stress resulting in severe wilting of the leaves. Prolonged periods of stress retard the normal activity of the bacterial blight organism in contrast to effects of favorable environmental conditions as just discussed.

Technique Used in Determining Resistance and Susceptibility

A number of investigators have classified the various types and varieties of cotton according to the degree of susceptibility to the bacterial blight disease. Blank (2), working in Texas, observed differences in varietal reaction to the disease ". . . highly susceptible varieties such as Acala, . . . varieties having considerable tolerance." Weindling (8), states, in discussion under the topic "Susceptibility or Resistance," ". . . if the tissues surrounding a given infection court are susceptible, the pathogenic bacteria will spread quickly and continuously; . . . in resistant tissues, spread is restricted so much that the lesions are very small, . . ."

From the standpoint of breeding for resistance, the primary purpose of this study was to establish resistance to bacterial blight in susceptible strains and varietal types; therefore, the populations, both segregating and non-segregating for resistance, were classified into either of two classes, resistant or susceptible (see Figures 1 and 2).

Spreading, water-soaked lesions of any size were considered an indication of susceptibility. The size of the lesions for certain varietal cross combinations varied from year to year; and the size of lesions was variable for different strains and varieties. For this study, the criterion of resistance was the absence of lesions on the leaves (other than pin point discolorations of the tissues). In some varietal crosses, the inoculated plants classified as resistant developed very small points of coloring, usually red or violet (antho-

cyanin coloring), apparent particularly in a cross involving BBR-3 x Hopi (see Figure 2). There was no apparent spread of infection from these points of coloring. Very little difficulty was encountered in distinguishing susceptible from resistant plants.

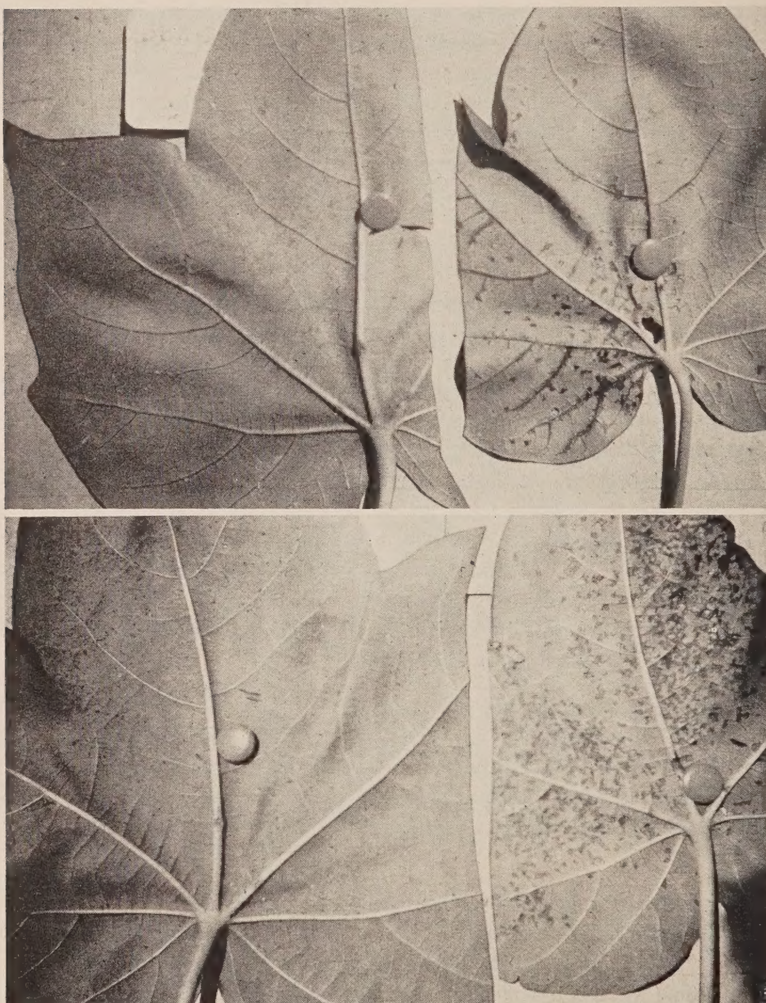

Fig. 1. The top picture shows leaves from strains resistant and susceptible to bacterial blight. Left, resistant strain BBR-3; right, susceptible variety Rowden Dortch No. 1. The bottom picture shows segregating resistance and susceptibility from the cross Acala Hopi x BBR-3. Left, leaf from resistant plant; right, leaf from susceptible plant.

Green boll tissues of resistant lines, particularly that portion covered by the bracts and the calyx, seemed less resistant than leaf tissue to the development of bacterial blight when the culture was applied under pressure to the boll. The organism gaining entry to

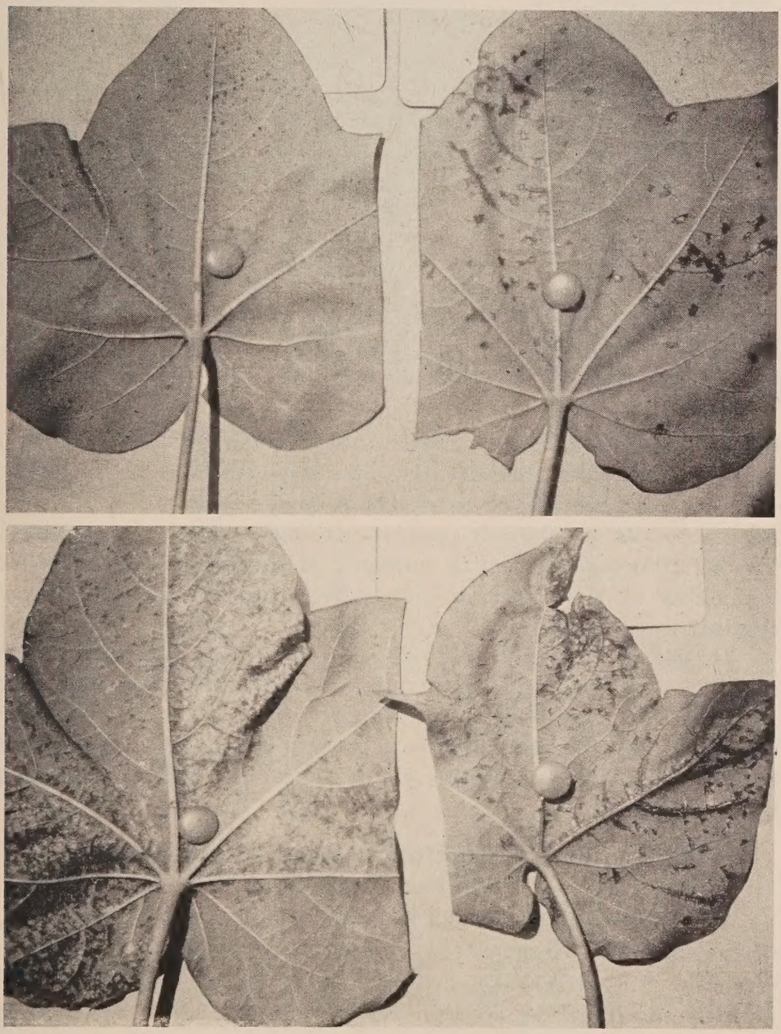

Fig. 2. Different types of infection. Top picture, leaves from the cross BBR-3 x Hopi. Left, leaf from resistant plant, on which pin-point areas of anthocyanin coloring may be observed; right, leaf from susceptible plant. Lower picture, left, all angular area infection; right, both angular and veining infection occurring at the same rate of development.

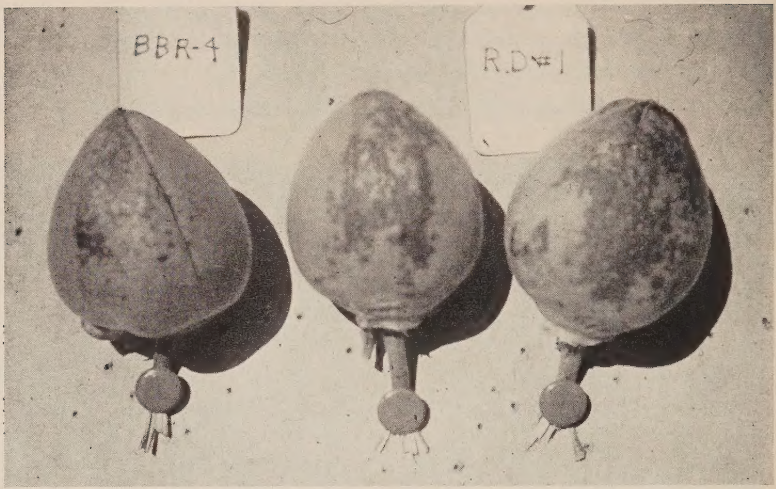

Fig. 3. Green bolls inoculated with the bacterial blight organism. Left, boll from resistant strain BBR-4; right, bolls from susceptible variety Rowden Dortch No. 1.

the boll tissues of the resistant lines developed to the extent of damaging the fiber; but the development seemed to be at a slower rate of spread and not as extensive as in the susceptible lines (see Figure 3). With inherent resistance to bacterial blight present in the leaf tissues, a damaging epidemic of bacterial blight would be less likely to occur than in cases where the entire plant was susceptible.

In the process of classifying the segregating population into resistant and susceptible plants, it was noted that when a resistant plant was found growing in the same hill with one or more susceptible plants, the resistant plant was generally smaller and appeared to be weaker. The susceptible plants appeared to have considerable hybrid vigor.

Differences in Vegetative Plant Characteristics and Fiber Properties

A thorough study of the progeny resulting from each of the three original resistant selections has revealed certain genetic differences. The differences are obvious to the extent that there is justification in giving a strain designation to each of the progeny lines. Thus, resistance to bacterial blight was found to be present in the genetic make-up of three strains selected out of a single variety. The differentiating characteristics of the strains are tabulated in Table 2.

TABLE 2. Vegetative Plant Characteristics, Lint Percentage, Lint and Seed Indices, and Fiber Properties of Bacterial-Blight-Resistant Strains BBR-1, BBR-3, and BBR-4

Characteristics and properties	BBR-1	BBR-3	BBR-4
Vegetative characteristics			
Plant type	Medium height, upright	Low, spreading	Tall, upright, rangy
Vegetative branches	Several	Few	Several
Fruiting branches	Intermediate length	Long	Long, internodes long
Boll size	Medium	Less than medium	Medium to large
Involucre-bracts, size	Medium	Medium to small	Large
Lint percentage	34.7	34.0	33.7
Lint index	7.3	7.3	6.9
Seed index	13.3	13.1	13.7
Fiber properties[1]			
Length, fibrograph			
UHM (upper half mean), inches	1.13	1.09	1.17
Mean, inches	.94	.90	.97
Fineness mm^2/mm^3, Arealometer	423	436	461
Strength, Pressley index	7.09	6.82	6.83

[1] Fiber analyses run by U. S. D. A. Fiber Laboratory, Knoxville, Tennessee; D. M. Simpson, Superintendent.

Breeding Behavior of Bacterial Blight Resistance

The progeny from the parental strains BBR-1, BBR-3, and BBR-4 were resistant throughout the experiment. In order to determine whether resistance in the three strains was governed by the same genetic factor or factors, the following crosses were made: BBR-1 x BBR-3, BBR-4 x BBR-1; and in the F_2 generation from the cross BBR-1 x BBR-3, two dissimilar appearing plants were crossed. The progenies from each cross, beginning with the F_1 generation and through the F_3 generation, were tested for susceptibility to bacterial blight. Out of 395 plants tested, only one plant was found susceptible.

Susceptible plants were occasionally found in generations produced from seed of the bacterial-blight-resistant stocks (Table 1). However, the susceptible plants discovered could have resulted from errors in the mechanics of self pollination by hand and in the process of harvesting the self-pollinated seed.

In order to maintain bacterial-blight-resistant strains in a state of purity, increase plots must be completely isolated from other cottons. Susceptible plants have been found in the second-year increase plots grown from seed produced in semi-isolated increase plots the previous year. In one instance, 29 plant selections were made and 11 of the plants proved to be natural hybrids.

Transfer of Bacterial Blight Resistance to Susceptible Strains and Varieties

In a cotton breeding program, it is desirable to have resistance to bacterial blight present in strains and varieties having various properties of economic importance. Examples of these properties include coarse, medium fine, and fine fiber; different lengths of fiber; storm-proofness; and glabrous and pubescent leaf surfaces. Having these and other special properties in combination with resistance to bacterial blight in basic breeding stocks would reduce the time necessary in breeding a new superior variety.

The strains carrying resistance to bacterial blight, BBR-1, BBR-3, and BBR-4, were crossed with susceptible strains and varieties primarily to substantiate the heritability of the indicated resistance and secondarily to incorporate resistance into cotton strains and varieties of economic importance.

To accelerate the process of transferring resistance to other strains and varieties, two generations were grown per year. During

the years 1947, 1948, 1949, and 1950, greenhouse facilities located at the University of Arkansas, Fayetteville, were utilized to produce a winter crop or the second crop per year. During the 1950-51 and 1951-52 winter seasons, the extra generation was produced under natural conditions at Iguala, Mexico. The generations grown in the greenhouse at Fayetteville and those grown at Iguala were not subjected to artificial epidemics of the bacterial blight organism.

Crosses Involving BBR-1

Crosses were made using BBR-1 as the source of resistance to bacterial blight. The F_1 generation in each case produced only susceptible plants. The F_2 generation from the initial cross produced susceptible and resistant plants. The proportion of susceptible plants to resistant plants in the F_2 populations approached a 3:1 ratio. The nearness to this ratio in a large number of populations strongly indicates that the resistant factor performs as a simple recessive character in inheritance. The proportion of susceptible plants to resistant plants was similar for crosses involving the resistant strains BBR-3 and BBR-4.

The resistant property carried by the strain BBR-1 was not altered by using BBR-1 as the male or female parent, indicating no cytoplasmic influence. Resistant plants used in backcrosses were visibly selected and resistance verified in following generations. The cross combinations made and plant classification results for the generations observed are given in Table 3.

Crosses Involving BBR-3

Strain BBR-3 differed significantly in plant characteristics from strains BBR-1 and BBR-4. It was more desirable as an economic varietal type; consequently, a larger number of crosses were made using BBR-3 as one parent in the resistance transfer work.

The plant reaction to artificial inoculation followed the regular pattern of the F_1 population plants being susceptible, and those produced in the F_2 or segregating generation being composed of both susceptible and resistant plants. The backcross was made by crossing a resistant plant in the segregating generation with either the susceptible or resistant parent of the original cross. For classification results see Table 4.

Crosses Involving BBR-4

Strain BBR-4 was the least desirable of the three lines developed from the standpoint of plant type, although it carried a high degree of resistance to bacterial blight. The resistance factor was readily transmitted to other strain types (see Table 5).

TABLE 3. Results from Crossing Bacterial-Blight-Resistant Strain Number 1 (BBR-1) with Strains of Cotton Susceptible to Bacterial Blight Disease

Cross combination	Filial generation					First backcross					Second backcross		Third backcross		Total plants class-ified
	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_1	F_2	
	Classification[1]														*Number*
BBR-1 x Roldo Rowden	S	R-S	R[2]	R	—	—	—	—	—	—	—	—	—	—	69
(Rowden M-2 x Rowden 17-2)F_1 x resistant plant from F_2 of Rowden 41-B x BBR-1	S	R-S	—	—	—	—	—	—	—	—	—	—	—	—	68
BBR-1 x Rowden 1-6-4	S	R-S	R	R	R	—	—	—	—	—	—	—	—	—	383
Resistant plant from F_2 of Rowden 41-B x BBR-1 crossed with Rowden M-12	S	R-S	—	—	—	—	—	—	—	—	—	—	—	—	113
(Rowden 41-B x BBR-1)F_1 backcrossed to Rowden 41-B; resulting F_2 resistant plant crossed to Rowden 41-B-100; F_1 susceptible plant from this cross backcrossed to Rowden 41-B-100	S	R-S	R	R	—	S	R-S	R	R	R	S	R-S	S	R-S	1,055
(Rowden 41-B x BBR-1)F_1 backcrossed to Rowden 41-B; resulting F_2 resistant plant crossed with Rowden 6015; a resistant plant from this cross backcrossed to Rowden 6015	S	R-S	—	—	—	S	R-S	R	—	—	—	R-S	—	—	265
Stormproof 4-6 x BBR-1		R-S	R	R	R	—	—	—	—	—	—	—	—	—	314
(BBR-1 x Stoneville E4-270)F_2; resistant plant from this cross backcrossed to Stoneville E4-270; resulting F_2 resistant plant backcrossed to Stoneville E4-270	S	R-S	R	R	—	S	R-S	—	—	—	S	—	—	—	293
(D&PL-041 x BBR-1)F_1 x D&PL Fox	S	R-S	R	—	—	S	—	—	—	—	—	—	—	—	59
(Acala-Rowden 108 x BBR-1)F_1 backcrossed to susceptible parent Acala-Rowden 108; resulting F_2 resistant plant backcrossed to parent Acala-Rowden 108; a third backcross made in a similar manner	S	R-S	R	R	R	S	R-S	R	—	—	S	R-S	S	R-S	970

[1] S denotes all plants susceptible; R denotes all plants resistant; R-S denotes segregation of resistant and susceptible plants.
[2] Only resistant plants were selected in the segregating generations to produce seed for subsequent generations.

TABLE 4. Results from Crossing Bacterial-Blight-Resistant Strain Number 3 (BBR-3) with Strains of Cotton Susceptible to Bacterial Blight Disease

Cross combination	Filial generation					First backcross				Second backcross		Total plants classified
	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_3	F_4	F_1	F_2	
	Classification[1]											*Number*
BBR-3-10 x Arkot-1	S	R-S	R_2	...	...	...		...	...			124
Acala W-29-1 x BBR-3-10	S	R-S	R	...	...	.	...		...	...	..	92
Resistant plant from the F_2 of a cross, BBR-3-10 x Acala 1517, backcrossed to Acala 1517	S	R-S	R			S	R-S	...			...	251
(BBR-3-10 x Stoneville E-11)F_1 x Stoneville E-11	S	R-S	R	...	...	S	R-S	...	...	...	...	159
Resistant plant from the F_2 of a cross, (Rowden 17-2 x Rowden 41-B) x BBR-3-10, backcrossed to Rowden 17-2	S	R-S	R	R	...	S	R-S	...	...	...	...	364
Resistant plant from the F_2 of a cross, Coker 100W x BBR-3-10, backcrossed to Coker 100W; resulting F_2 resistant plant backcrossed again to Coker 100W	S	R-S	R	R	R	S	R-S	R	...	S	R-S	983
Resistant plant from the F_2 of a cross, BBR-3-10 x Hopi, backcrossed to BBR-3-10; second backcross made to BBR-3-10	S	R-S	R	R	...	R	R	R	...	R	R	459
(AHA x Coker 100 W x Coker 100W) x BBR-3-15	...	R-S	...	...	...	...	...	...	...	...	...	151
Resistant plant from the F_2 of a cross, Acala-Hopi x BBR-3-10, backcrossed to BBR-3-10	S	R-S	R	R	...	R	R	R	...	...	...	445
Resistant plant from the F_2 of a cross, Nucala-Rowden 13-10 x BBR-3-10, backcrossed to Nucala-Rowden 13-10; resistant plant of resulting F_2 backcrossed to Nucala-Rowden 13-10	S	R-S	R	R	R	S	R-S	R	..	S	...	1,270
Nucala-Rowden 11-8 x BBR-3-10	S	R-S	R	R	...	...	...	...	...	...	...	167
(Stoneville E-11 x Coker Wilds 9) x BBR-3-15	S	R-S	...	...	...	...	...	...	...	...	...	150
Resistant plant from the F_2 of a cross, BBR-3-15 x Nucala-Rowden 20, backcrossed to Nucala-Rowden 20; susceptible plant of resulting F_1 backcrossed to Nucala-Rowden 20	S	R-S	R	...	...	S	R-S	R	...	S	R-S	313
(BBR-3-15 x Acala Rogers)F_1 x Acala Rogers	S	R-S	R	...	...	S	R-S	...	...	...	...	228
(BBR-3-15 x Empire W. R.)F_1 x Empire W. R.; resistant plant of resulting F_2 backcrossed to Empire W. R.	S	R-S	...	R	...	S	R-S	R	...	S	R-S	329
(BBR-3-15 x Missdel-Acala 23)F_1 x Missdel-Acala 23	S	R-S	...	...	...	...	R-S	...	...	...	...	90
(Stoneville E4-010 x Coker 100W) x BBR-3-10	S	R-S	R	...	...	...	...	...	...	...	...	37

Continued

TABLE 4. Results from Crossing Bacterial-Blight-Resistant Strain Number 3 (BBR-3) with Strains of Cotton Susceptible to Bacterial Blight Disease (continued)

Cross combination	Filial generation					First backcross				Second backcross		Total plants classified
	F_1	F_2	F_3	F_4	F_5	F_1	F_2	F_3	F_4	F_1	F_2	
	Classification[1]											*Number*
Resistant, smooth-leaf plant from the F_2 of the cross, Smooth Leaf Dwarf x BBR-3-15, backcrossed to BBR-3-15	S	R-S	—	R	—	R	R	—	—	—	—	1,071
BBR-3-15 x Empire P-46	S	R-S	—	—	—	—	—	—	—	—	—	137
Resistant plant from the F_2 of a cross, Lone Star P-4-1 x BBR-3-10, backcrossed to Lone Star P-4-1	S	R-S	...	...	...	S	R-S	...	...	...	...	108
(BBR-3-10 x Delfos 651)F_1 x Delfos 651	S	R-S	—	—	—	S	R-S	—	—	—	—	77
BBR-3-15 x Paymaster 54	S	R-S	—	—	—	—	—	—	—	—	—	81
BBR-3-15 x Paula	S	R-S	—	—	—	—	—	—	—	—	—	64
(Acala W-29-1 x BBR-3-10)F_1 x Acala 1517 W. R.	S	R-S	—	—	—	S	R-S	—	—	—	—	295

[1] S denotes all plants susceptible; R denotes all plants resistant; R-S denotes segregation of resistant and susceptible plants.
[2] Only resistant plants were selected in the segregating generations to produce seed for subsequent generations.

TABLE 5. Results from Crossing Bacterial-Blight-Resistant Strain Number 4 (BBR-4) with Strains of Cotton Susceptible to Bacterial Blight Disease

Cross combination	Filial generation: Initial cross			Backcross		Total plants classified
	F_1	F_2	F_3	F_1	F_2	
	Classification[1]					*Number*
(BBR-4 x Missdel-Acala)F_1 x BBR-4	S	R-S	R[2]	S	R-S	108
(BBR-4 x Coker Wilds 9)F_1 x Coker Wilds	S	R-S	—	S	R-S	67
Smooth Leaf Dwarf x BBR-4	S	R-S	R-S[3]		.	111

[1] S denotes all plants susceptible; R denotes all plants resistant; R-S denotes segregation of resistant and susceptible plants.
[2] Resistant plants were selected in the segregating generations to produce seed for subsequent generations.
[3] Susceptible plant selected in previous generation.

Yields of Resistant Strains in Comparison to Commercial Varieties

The yielding properties of strains BBR-1 and BBR-3 have been tested in various strain and variety tests. The yield performance of these strains indicates they are average to above average in this respect (Tables 6 and 7). Testing in other states, especially in Texas where natural infection is usually heavy, indicates a production performance ranging from average to good. For the sake of brevity and reduction of tabular space, check plot yields are shown for only one or two varieties. The check varieties are commercial types that have consistently been among the best yielding sorts.

TABLE 6. Yield and Other Properties of Lines Resistant to Bacterial Blight, Compared with Productive Commercial Varieties, in Strains Tests at Marianna and Clarkedale, 1948-50

Strains and varietal checks	Acre yield: Seed cotton	Acre yield: Lint	Staple length	Gin turn-out	Bolls per pound seed cotton	Earliness[1]
	Pounds	*Pounds*	*Inches*	*Per cent*	*Number*	*Per cent*
Preliminary Strain Tests						
1948, Cotton Branch Station, Marianna						
BBR-3	1,948	651	$1\frac{3}{32}$	33.4	......	......
BBR-1	1,936	627	$1\frac{1}{8}$	32.4	......	......
Stoneville 2B	1,750	585	$1\frac{1}{8}$	33.4		
1949, Cotton Branch Station, Marianna						
BBR 3-10	2,380	845	$1\frac{1}{16}$	35.5	68.2	84.5
BBR 3-2	2,519	887	$1\frac{1}{16}$	35.2	67.0	83.2
BBR 3-10-6	2,519	887	1	35.2	66.6	81.4
BBR 1-A 3	2,549	905	$1\frac{1}{16}$	35.5	60.4	74.1
Arkot 2-1	2,767	946	$1\frac{1}{16}$	34.2	62.9	88.5
D & PL 041	2,408	864	$1\frac{1}{16}$	35.9	72.9	83.9
1949, Delta Substation, Clarkedale						
BBR 3-10	2,018	670	$1\frac{3}{32}$	33.2	66.8	76.8
BBR 3-2	1,982	662	$1\frac{1}{8}$	33.4	67.2	75.0
BBR 3-10-6	2,526	849	$1\frac{1}{8}$	33.6	67.7	72.1
BBR 1-A 3	2,107	706	$1\frac{3}{32}$	33.5	58.0	66.8
Arkot 2-1	1,946	631	$1\frac{5}{32}$	32.4	64.1	69.0
D & PL O41	2,003	679	$1\frac{1}{8}$	33.9	65.7	71.1
1950, Cotton Branch Station, Marianna						
BBR 3-2	1,918	725	1	37.8	63.2	
BBR 3-15-12	1,809	671	$1\frac{1}{32}$	37.1	64.0	
D & PL Fox	2,124	801	$1\frac{1}{32}$	37.7	64.3	
Empire WR	2,529	966	$1\frac{1}{32}$	38.2	51.9	...
New Strain Test						
1950, Cotton Branch Station, Marianna						
BBR 3-2	2,058	780	$1\frac{1}{32}$	37.9	63.6	43.4
BBR 3-10	2,018	773	$1\frac{1}{32}$	38.3	64.6	37.2
BBR 3-11	2,391	918	$1\frac{1}{32}$	38.4	64.6	53.8
BBR 3-15-12	2,304	880	$1\frac{1}{32}$	38.2	64.4	48.8
Empire WR	2,516	984	$1\frac{1}{16}$	39.1	54.9	63.8
Stoneville 2B	2,415	925	$1\frac{3}{32}$	38.3	59.9	47.4

[1] Per cent of total crop on first picking.

In the process of testing strains developed from BBR-1 and BBR-3 parent material, one line in particular has appeared consistently uniform in plant type and average to good in yield perfor-

TABLE 7. Yield and Other Properties of Lines Resistant to Bacterial Blight, Compared with Productive Commercial Varieties, in Commercial Variety Tests at Marianna, Clarkedale, and Craighead County, 1949 and 1950

Strains and varietal checks	Acre yield: Seed cotton	Acre yield: Lint	Staple length	Gin turn-out	Bolls per pound seed cotton	Earliness[1]
	Pounds	*Pounds*	*Inches*	*Per cent*	*Number*	*Per cent*
1949, Cotton Branch Station, Marianna						
BBR-1	2,972	942	$1\frac{1}{16}$	31.7	56.7	67 7
BBR-3	3,134	1,009	$1\frac{1}{16}$	32.2	63.0	77.5
Empire WR	2,922	941	$1\frac{1}{16}$	32.2	52.4	76.2
Stoneville 2B	3,018	999	$1\frac{1}{16}$	33.1	60.8	77.2
1949, Delta Substation, Clarkedale (Sandy loam soil)						
BBR-1	1,666	523	$1\frac{1}{32}$	31.4	57.6	65.0
BBR-3	1,682	545	$1\frac{1}{32}$	32.4	63.2	65.9
Empire WR	1,856	612	$1\frac{1}{16}$	33.0	53.4	68.4
Stoneville 2B	1,609	525	$1\frac{1}{16}$	32.6	62.2	58.0
1949, Delta Substation, Clarkedale (Clay soil)						
BBR-1	607	208	$1\frac{1}{32}$	34.2	72.8	84.4
BBR-3	566	195	$1\frac{1}{32}$	34 4	77.4	88.0
Empire WR	726	253	$1\frac{1}{32}$	34.9	73.2	85.2
Stoneville 2B	646	220	$1\frac{1}{32}$	34.0	75.2	79.7
1950, Cotton Branch Station, Marianna						
BBR-3	2,386	854	$1\frac{1}{16}$	35.8	—	—
Empire WR	2,460	930	$1\frac{1}{16}$	37.8	..	..
Stoneville 2B	2,032	723	$1\frac{3}{32}$	35.6	—	—
1950, Delta Substation, Clarkedale (Sandy loam soil)						
BBR-3	1,108	383	$1\frac{1}{16}$	34.6	66.5	69.7
Empire WR	1,635	585	$1\frac{3}{32}$	35.8	53.5	79.4
Stoneville 2B	1,225	417	$1\frac{3}{32}$	34.0	56.2	66.0
1950, Delta Substation, Clarkedale (Clay soil)						
BBR-3	887	317	$1\frac{1}{32}$	35.7	83.6	87.6
Empire WR	991	372	$1\frac{1}{16}$	37.5	63.7	92.6
Stoneville 2B	913	320	$1\frac{1}{8}$	35.1	74.1	87.3
1950, Craighead County						
BBR-3	1,128	406	$1\frac{1}{32}$	36.0	77.4	—
Empire WR	910	330	$1\frac{1}{16}$	36.3	69.0	—
Stoneville 2B	1,309	465	$1\frac{3}{32}$	35.5	66.1	.

[1] Per cent of total crop on first picking.

mance. This line carries the strain number BBR-3-15-12, and the seed stock has been increased for further testing. Comparative yield data are given in Table 6. The original plant selection of this strain is shown on the back cover.

Spinning Test Results

The spinning test results show differences in the fiber produced by the bacterial-blight-resistant strains. The strain BBR-4 has the longest fiber and BBR-3 the shortest, with BBR-1 occupying an intermediate position. The fiber of strain BBR-4 is significantly finer than the fiber of the other strains. In terms of spinnability, the differences shown probably would not be significant.

The spinning test results give a higher picker and card waste for the BBR-4 strain. This condition may or may not be attributed to fineness. Spinning test analyses are given in Table 8, as are also the fiber properties of a more recent derivative, BBR 3-15-12, out of the original BBR-3 strain.

TABLE 8. Fiber and Spinning Properties of Strains of Cotton Resistant to Bacterial Blight[1]

Properties	1948			1950
	BBR-1	BBR-3	BBR-4	BBR 3-15-12
Fiber properties				
Sample from gin				
Classer's designation				
Grade	SM	GM	SM	GM
Staple (inches)	1 3/32 (1.09)	1 3/32 (1.09)	1⅛ (1.12)	1 (1.00)
Fibrograph measurements				
UHM (inches)	1.16	1.11	1.19	1.11
M (inches)	.94	.88	.92	.94
Pressley index	6.93	6.48	6.34	6.40
Specific surface area (cm^2/mg)	2.82	2.82	3.04	434[2]
Second drawing sliver				
Fibrograph measurements				
UHM (inches)	1.22	1.17	1.26	1.16
M (inches)	.99	.97	1.02	.98
Pressley index	7.34	6.86	7.37	6.4
X-ray angle	33.3	34.2	37.2	
Specific surface area ($cm^2/mg.$)	2.77	2.92	3.10	430[2]
Spinning properties				
Skein strength				
22's	119	117	118	110
36's	66	64	65	62
50's	43	43	42	40
Yarn appearance grade (mean of three counts)	4.7 (B)	5.3 (B)	6.0 (B-)	4.0 (B+)
Neps in card web	4	4	6	5
Picker and card waste (per cent)	5.52	6.31	8.61	5.10

[1] Progress report on the annual varietal and environmental study of fiber and spinning properties of cotton, 1948 and 1950 crops respectively. Prepared in the Division of Cotton and Other Fiber Crops and Diseases, U. S. Department of Agriculture, Agriculture Research Administration, Bureau of Plant Industry, Soils and Agriculture Engineering.

[2] Surface area measured as mm^2/mm^3 by Arealometer.

SUMMARY

A survey, in several commercial varieties, of bolls damaged by bacterial blight clearly indicated different degrees of susceptibility. This resulted in the motivation of a plan to select for resistant plants within commercial varieties.

Selection for resistant plants within Stoneville 2B resulted in finding plants highly resistant. These selections were propagated for use in further breeding work.

Epidemics of bacterial blight were artificially induced by spraying the plants with an inoculum prepared from cultures of the organism. Also, a watery suspension of the bacteria was prepared from naturally infected leaves gathered from the field and used as inoculum.

In the breeding program, plants were classified as resistant or susceptible. No attempt was made to use a gradation technique in evaluating different degrees of resistance or susceptibility exhibited by the plants.

Differences in characteristics of progeny lines BBR-1, BBR-3, and BBR-4 were obvious enough to justify a strain designation for each.

Resistance to bacterial blight carried by the resistant strains was found to be homozygous by inter-crossing the strains and testing resulting progeny.

Bacterial blight resistance carried by each of the resistant strains was successfully transferred to susceptible strains and varieties. The resistant plants, segregating out, bred true under conditions of isolation.

The yielding properties of strains BBR-1, BBR-3, and BBR 3-15-12 were found to be equal, and in some cases superior, to that of the parental type.

The spinning properties of the fiber produced by the resistant strains was found to be satisfactory in comparison with standard commercial varieties.

Breeding lines have been established that are resistant to bacterial blight and have varied economic properties. Use of these basic breeding stocks should greatly reduce the time required to develop new and resistant strains.

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NOTE

It is not likely that any of the resistant strains developed and reported on in this paper, will be released for commercial production. They are being used in the breeding of varieties superior to those in current production. A small amount of seed will be maintained from the resistant stocks for breeding purposes.

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The Cotton Division Photographic Laboratory, Beltsville, Md., reproduced the black-and-white photographs from colored pictures taken by the author.

Fig 4.   Original plant selection of the strain BBR-3-15-12, made in 1948.